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Original article

Reliability assessment of measuring active wrist pronation and supination range of motion with a smartphone

Évaluation de la fiabilité de la mesure des amplitudes de mouvement actif de pronation et de supination avec un smartphone

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ABSTRACT

This study aimed to improve clinical examination techniques by determining the reliability of different methods to evaluate forearm movements. Two methods using the iPhone™ 5 and its gyroscope application (alone [I5] or attached to a selfie stick [ISS]) were compared with two conventional measurement devices (a plastic goniometer with a hand-held pencil [HHP] and a bubble goniometer [BG]) to evaluate the active range of movement (AROM) of the wrist during pronation and supination. Two independent groups of subjects took part in this prospective single-center diagnostic study: 20 healthy subjects and 20 patients. The four evaluation methods had high intra-observer consistency after three measurements (intra-class correlation coefficient [ICC] [3, 1] of 0.916 for the HHP; 0.944 for ISS; 0.925 for BG; 0.933 for I5) and excellent inter-observer reliability (ICC [2, k] of 0.926 for HHP; 0.934 for ISS; 0.899 for BG; 0.894 for I5), with an agreement of plus or minus 2°. When these devices are used with rigorous methodology, they are reliable for the goniometric evaluation of AROM of wrist pronation and supination.

Mots clés :
Pronation
Supination
Évaluation goniométrique
IPhone
Fiabilité

RÉSUMÉ

Cette étude cherchait à améliorer la technique de l'examen clinique en déterminant la fiabilité de différentes méthodes fonctionnelles pour évaluer le mouvement de l'avant-bras. Deux modalités d'utilisation de l'iPhone™ 5 et l'application gyroscope (seul [I5] et attaché sur une perche à selfie [ISS]) ont été comparées à deux dispositifs de mesures conventionnels (goniomètre plastique et une tige maintenue dans la main [HHP], et goniomètre à bulle [GB]) pour évaluer les amplitudes actives des mouvements (AROM) de pronation et de supination du poignet. Deux groupes indépendants de sujets ont participé à cette étude diagnostique prospective monocentrique : 20 sujets sains et 20 malades. Les résultats montrent que les quatre méthodes d'évaluation présentaient une cohérence intraobservateur élevée après trois prises de mesures (coefficient de corrélation intra-classe (3, 1) : 0,916 pour HHP ; 0,944 pour ISS ; 0,925 pour BG ; 0,933 pour I5 respectivement) et une excellente fiabilité interobservateur (coefficient de corrélation intra-classe (2, k) : 0,926 pour HHP ; 0,934 pour ISS ; 0,899 pour BG ; 0,894 pour I5 respectivement), avec un accord de plus ou moins 2°. Utilisés avec rigueur méthodologique, ces outils sont fiables pour l'évaluation goniométrique des AROM de l'avant-bras en pronation et en supination chez des sujets présentant des blessures récentes.

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1. Introduction

To measure the active range of movement (AROM) of the forearm in pronation and supination, Karagiannopoulos et al. [1] studied the reliability of two functional goniometric methods: the plumb-line goniometer (PLG) (Fig. 1) and the hand-held pencil (HHP) (Fig. 2). These are the only devices that can be used to measure functional pronation and supination. In that study, the two methods were extremely reliable for measuring AROM in subjects with and without injury. The PLG used in the Karagiannopoulos study is not commercially available. Since HHP instruments are readily available in a clinical context, this is the method of choice. In 2014, Kim et al. [2] reported measuring wrist ROM with the iPhone™ 4 and its gyroscope application. Based on that study, it should be possible to use this device to measure ROM in other joints. In 2001, Gajdosik et al. [3] showed that the HHP method was the most reliable, but was not suitable for measuring supination because of movement of the 4th and 5th metacarpal bones.

The aim of this study was to determine the reliability of different methods to evaluate forearm movements: the Karagiannopoulos et al. method with the HHP [1] and the device used par Kim et al. [2], the iPhone™, which is widely used in France and around the world [4], and the bubble goniometer (BG). For the iPhone™, two methods were tested: the iPhone™ alone (I5) or an iPhone attached to a selfie stick (ISS), both of which can be easily manipulated by all subjects.

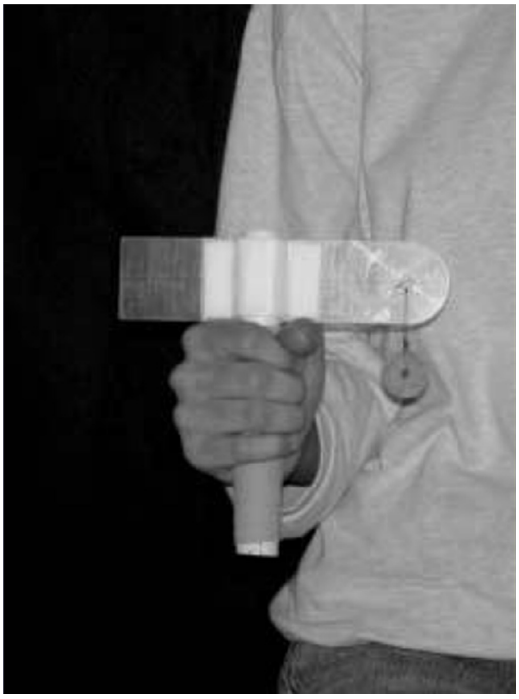

Fig. 1. Plumb-line goniometer (PLG) method.

Fig. 2. Hand-held pencil (HHP) method.

2. Materials and methods

To ensure that results would be comparable, the methodology described by Karagiannopoulos et al. [1] was followed exactly.

2.1. Population

Two independent groups of subjects took part in this prospective single-center diagnostic study. The subjects read and signed the informed consent form before being enrolled in the study.

The first group was a sample of 20 subjects (10 men, 10 women) suffering from injury to the hand, wrist, forearm or elbow and treated at our hand rehabilitation unit. They took part in the tests after 1 to 10 weeks immobilization following the injury. This group was used to determine the repeatability and reproducibility of different methods in an injured population: HHP compared with ISS and BG compared with I5. The exclusion criteria were as follows:

- neurological diseases causing paralysis or paresthesia of the arm;
- pain or deformation due to rheumatoid disease;
- musculoskeletal disorders affecting the hand, wrist, forearm, or elbow not treated by immobilization;
- inability to touch the distal palmar crease with the pads of the long fingers when making a fist.

The second group was a sample of 20 subjects without hand injury (10 men, 10 women). This group was used to determine the repeatability and reproducibility of different methods in an uninjured population: HHP compared with ISS and BG compared with I5. All the subjects were patients at the unit mentioned above. The exclusion criteria for the subjects in this group were limited to neurological diseases, the complications of rheumatoid disease and musculoskeletal injury of the upper limb.

2.2. Instruments

Demographic data were collected: subject's age, gender and dominant hand, the presence of inclusion and exclusion criteria. The dominant hand was determined using the modified Edinburgh dominance inventory [5] questionnaire based on everyday activities. Dominance was defined as the hand with the largest number of positive responses. AROM values in pronation and supination measured using the four methods and for each subject were recorded on a separate form by each tester. This was done autonomously and independently to minimize tester bias.

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